TO START THIS MATHEMATICA NOTEBOOK YOU CLICK ITS FILENAME.
You will have to use a computer in a university lab (e.g. Wells Hall B-Wing)

This *Mathematica* notebook contains a number of useful functions described in the handout and briefly indicated below. The first time you attempt to use one of these functions a panel will pop up asking "Do you want to evaluate all the initialization cells?" to which you must answer yes.

To enter a given command line you click on the screen whereupon a horizontal line should appear at the cursor. When right brackets are in view on the *Mathematica* panel you want to click at a place where a horizontal line will extend between two such brackets if you desire a new line. If you attempt to type multiple commands into a single bracketed location *Mathematica* will become confused.

Type the command you wish to execute then PRESS THE ENTER KEY ON THE NUMERIC KEYPAD. This is required because *Mathematica* wants to use the return or other enter key to move to the next line. You do nor want to move to a new line. You want to enter a command. That is why you must use the ENTER key on the numeric keypad.

To save your work select save from the pull down file menu, which saves it as a *Mathematica* .nb (notebook) file. If you wish to print your work at home select print then the option of saving as a PDF. You will be unable to work with the .nb *Mathematica* file itself unless you have *Mathematica* installed (unlikely) but you can transport and print the .pdf file virtually anywhere.

Click the line below and press ENTER on the numeric keypad.

```
In[40]:= size[{4.5, 7.1, 7.8, 9.1}]

Out[40]= 4
```

Just above, I clicked to open a new line then typed
size[{4.5, 7.1, 7.8, 9.1}]
followed by a press of the numeric keypad ENTER key. Notice that off to the right of the entry there are nested brackets joining the command line and its output 4 = the number of data items in {4.5, 7.1, 7.8, 9.1}.

▪ A complete list of the commands in this notebook and what they do.

size[{4.5, 7.1, 7.8, 9.1}] returns 4
mean[{4.5, 7.1, 7.8, 9.1}] returns the mean 7.125
median[{4.5, 7.1, 7.8, 9.1}] returns the median of the list {4.5, 7.1, 7.8, 9.1}
s[{4.5, 7.1, 7.8, 9.1}] returns the sample standard deviation s=1.93628
sd[{4.5, 7.1, 7.8, 9.1}] returns the n-divisor version of standard deviation s=1.67686
r[x, y] returns the sample correlation r = $\frac{\overline{xy} - \overline{x}\,\overline{y}}{\sqrt{\overline{x^2} - \overline{x}^2}\,\sqrt{\overline{y^2} - \overline{y}^2}}$ for paired data.
sample[{4.5, 7.1, 7.8, 9.1}, 10] returns 10 samples from `{4.5, 7.1, 7.8, 9.1}`
ci[{4.5, 7.1, 7.8, 9.1}, 1.96] returns a 1.96 coefficient CI for the mean from given data
bootci[mean, {4.5, 7.1, 7.8, 9.1}, 10000, 0.95] returns 0.95 bootstrap ci for pop mean
smooth[{4.5, 7.1, 7.8, 9.1}, 0.2] returns the density for data at bandwidth 0.2
smooth2[{4.5, 7.1, 7.8, 9.1}, 0.2] returns the density for data at bandwidth 0.2
overlaid with normal densities having sd = 0.2 around each data value
smoothdistribution[{{1, 700},{4 ,300}}, 0.2] returns the density at bandwidth 0.2
for a list consisting of 700 ones and 300 fours.
popSALES is a file of 4000 sales amounts used for examples
entering **popSALES** will spill 4000 numbers onto the screen. To prevent
that enter **popSALES;** instead (the appended semi-colon suppresses output).
betahat[matrix x, data y] returns the least squares coefficients $\hat{\beta}$ for a fit of the model y = x $\beta + \epsilon$.
resid[matrix x, data y] returns the estimated errors $\hat{\epsilon}$ = y - x$\hat{\beta}$ (see **betahat** above).
R[matrix x, data y] returns the **multiple correlation** between the fitted values x$\hat{\beta}$ and data y.
xquad[matrix x] returns the full quadratic extension of a design matrix with constant term
xcross[matrix x] returns the extension of x to include all products of differing columns.

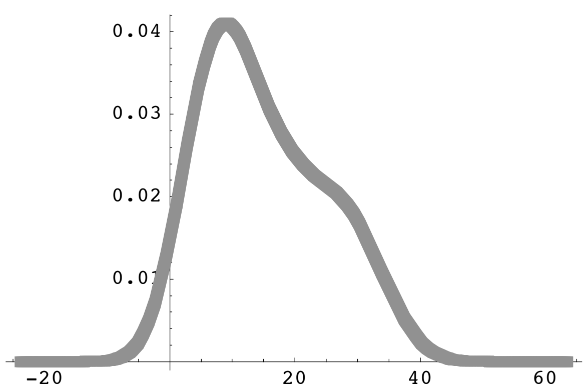
```
In[20]:= Mean[popSALES]

Out[20]= 15.1267

In[21]:= sd[popSALES]

Out[21]= 9.3817
```

The next line finds a sample of 40 from popSALES. The line below that finds a 95% z-CI for the population mean. It outputs {mean, n, s, z (or t), CI}.

In *Mathematica* the percent character % refers to the output of the very last command execution.

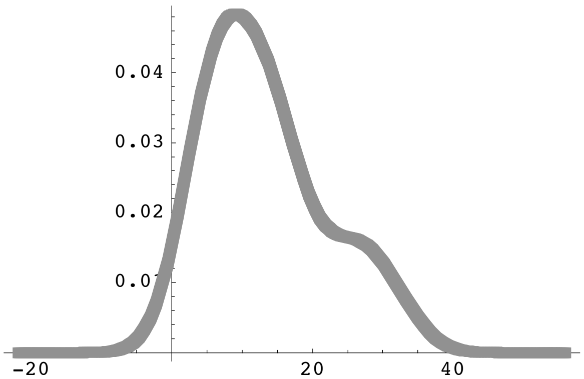
```
In[22]:= mysample = sample[popSALES, 40];

In[23]:= ci[mysample, 1.96]

Out[23]= {13.3278, 40., 8.26092, 1.96, {10.7677, 15.8878}}
```

```
In[24]:= bootci[mean, mysample, 10000, 0.95]

Out[24]//MatrixForm=
  Confidence Level            0.95
  Estimator                   mean
  Estimate                    13.3278
  Sample Size                 40
  bs Replications #1          10000
  bootstrap C ci Half Width   2.502
  CI                          {10.8257, 15.8298}

In[25]:= median[popSALES]

Out[25]= 12.975

In[26]:= median[mysample]

Out[26]= 12.15

In[27]:= bootci[median, mysample, 10000, 0.95]

Out[27]//MatrixForm=
  Confidence Level            0.95
  Estimator                   median
  Estimate                    12.15
  Sample Size                 40
  bs Replications #1          10000
  bootstrap C ci Half Width   3.685
  CI                          {8.465, 15.835}

In[28]:= smooth[popSALES, 4]
```

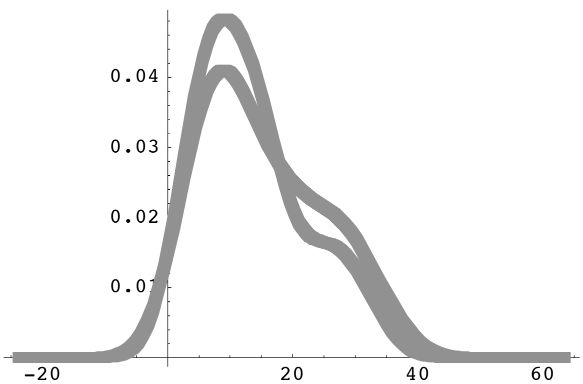



```
Out[28]= - Graphics -
```

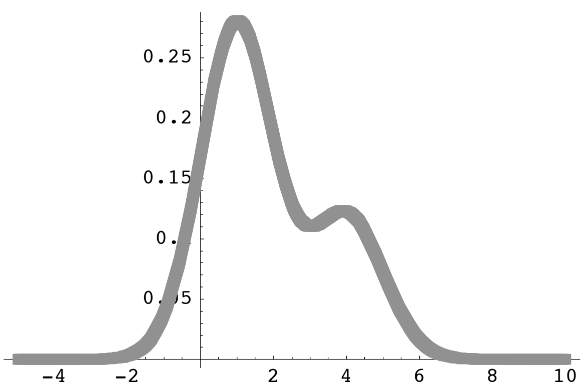
```
In[29]:= smooth[mysample, 4]
```




```
Out[29]= - Graphics -

In[30]:= Show[%, %%]
```




```
Out[30]= - Graphics -

In[31]:= smoothdistribution[{{1, 700}, {4, 300}}, 1]
```



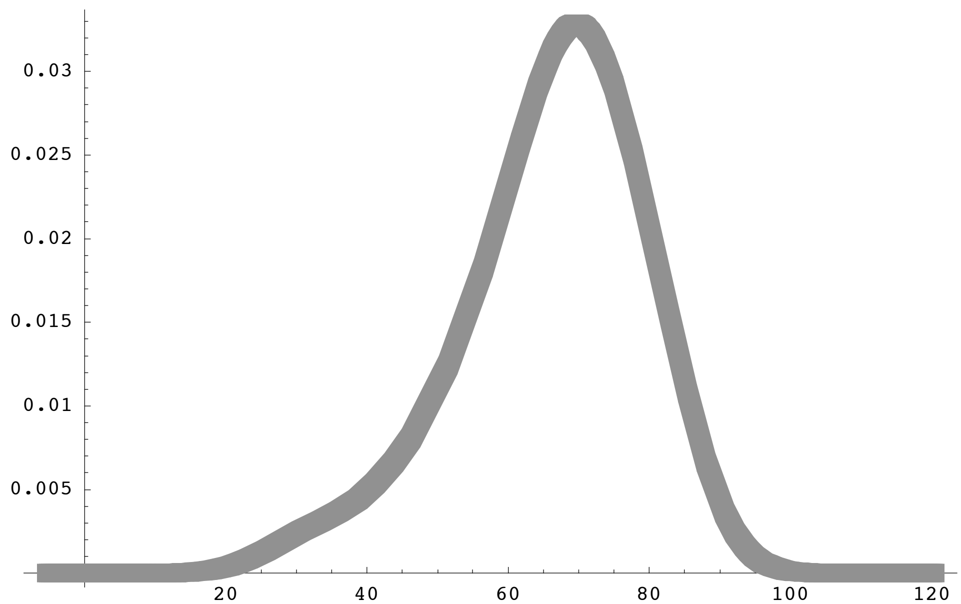

```
Out[31]= - Graphics -
```

Reproducing the curves of Figure 7.13 produced by smoothing data {84,49,61,40,83,67,45,66,70,69,80,58,68,60,67,72,73,70,57,63,70,78,52,67,53,67,75,61,70,81,76,79,75,76,58,31} according to the method:

bandwidth = λ time the sample standard deviation of data, for the two values λ = 0.5 and λ = 0.2.

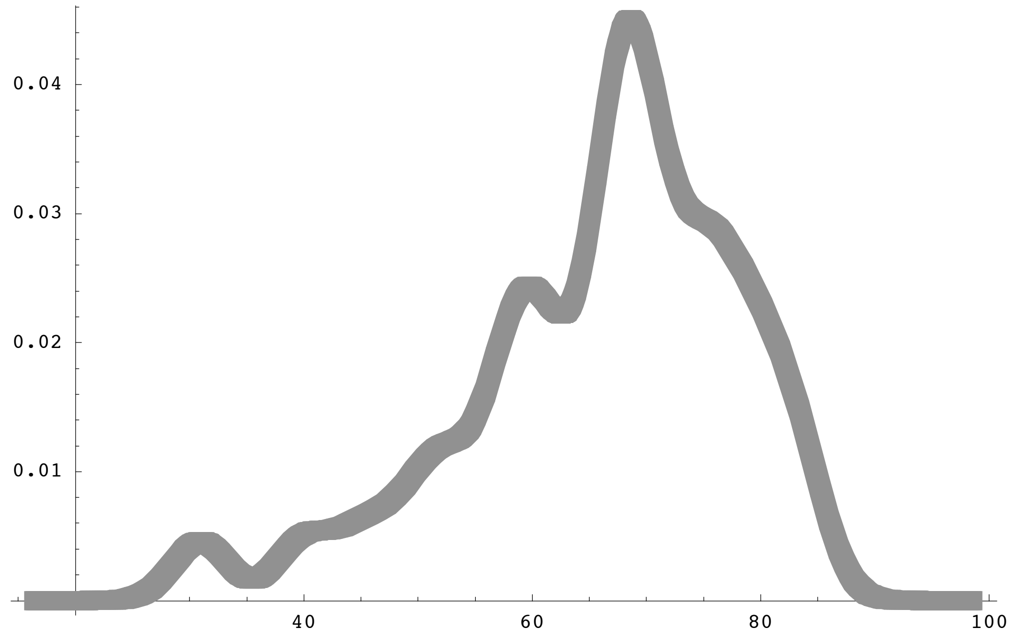
Sample standard deviation of a list of numbers is defined on pg. 71. It may be computed:
s[{84,49,61,40,83,67,45,66,70,69,80,58,68,60,67,72,73,70,57,63,70,78,52,67,53,67,75,61,70,81,76,79,75,76,58,31}]
which returns sample standard deviation 12.1588 (just below).

```
In[32]:= s[{84, 49, 61, 40, 83, 67, 45, 66, 70, 69, 80, 58, 68, 60, 67, 72, 73,
           70, 57, 63, 70, 78, 52, 67, 53, 67, 75, 61, 70, 81, 76, 79, 75, 76, 58, 31}]

Out[32]= 12.1588

In[33]:= smooth[{84, 49, 61, 40, 83, 67, 45, 66, 70, 69, 80, 58, 68, 60, 67, 72, 73, 70, 57,
           63, 70, 78, 52, 67, 53, 67, 75, 61, 70, 81, 76, 79, 75, 76, 58, 31}, .5 12.1588]
```




```
Out[33]= - Graphics -
```

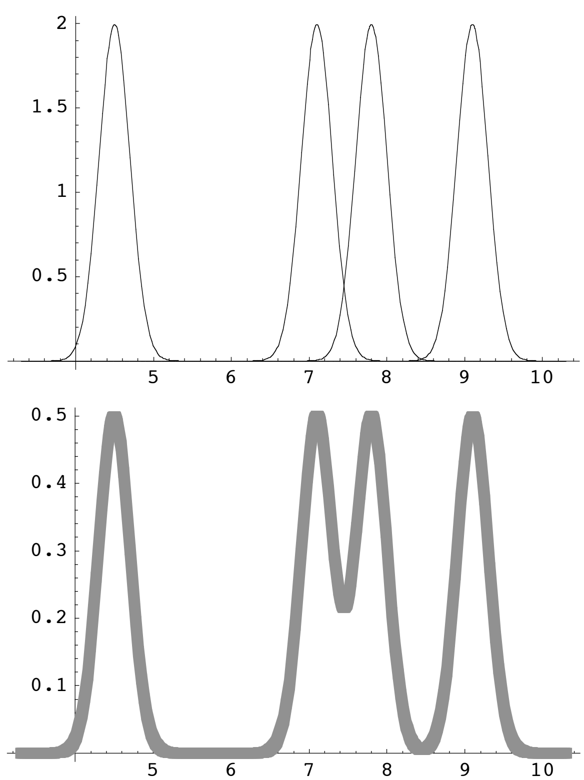
```
In[34]:= smooth[{84, 49, 61, 40, 83, 67, 45, 66, 70, 69, 80, 58, 68, 60, 67, 72, 73, 70, 57,
           63, 70, 78, 52, 67, 53, 67, 75, 61, 70, 81, 76, 79, 75, 76, 58, 31}, .2 12.1588]
```

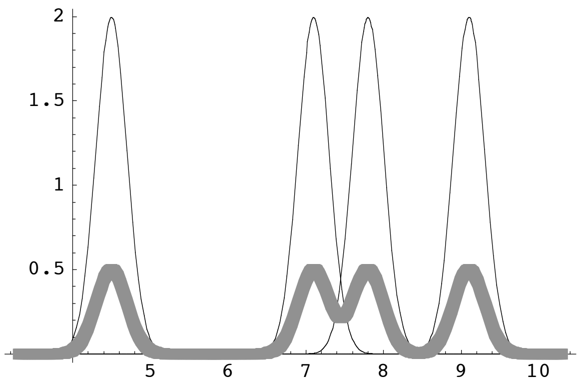



```
Out[34]= - Graphics -
```

The figures just above are indeed those of Figure 1.13.pg. 335.

```
In[35]:= smooth2[{4.5, 7.1, 7.8, 9.1}, 0.2]
```





Out[35]= - Graphics -

In[36]:= **R**[{{1, 2}, {1, 3}, {1, 6}}, {9, 7, 5}]

Out[36]= 0.960769

In[37]:= **r**[{2, 3, 6}, {9, 7, 5}]

Out[37]= -0.960769

In[38]:= **betahat**[{{1, 2}, {1, 3}, {1, 6}}, {9, 7, 5}]

Out[38]= $\left\{\frac{135}{13}, -\frac{12}{13}\right\}$

In[39]:= **resid**[{{1, 2}, {1, 3}, {1, 6}}, {9, 7, 5}]

Out[39]= $\left\{\frac{6}{13}, -\frac{8}{13}, \frac{2}{13}\right\}$

In[242]:=

MatrixForm[{{1, a, b, c}, {1, A, B, C}, {1, ay , be, si}, {1, AY, BE, SI}}]

Out[242]//MatrixForm=

$$\begin{pmatrix} 1 & a & b & c \\ 1 & A & B & C \\ 1 & ay & be & si \\ 1 & AY & BE & SI \end{pmatrix}$$

In[243]:=

xquad[{{1, a, b, c}, {1, A, B, C}, {1, ay , be, si}, {1, AY, BE, SE}}]

Out[243]=

$\{\{1, a, b, c, a^2, a\,b, a\,c, b^2, b\,c, c^2\}, \{1, A, B, C, A^2, A\,B, A\,C, B^2, B\,C, C^2\},$
$\{1, ay, be, si, ay^2, ay\,be, ay\,si, be^2, be\,si, si^2\},$
$\{1, AY, BE, SE, AY^2, AY\,BE, AY\,SE, BE^2, BE\,SE, SE^2\}\}$

In[244]:=

MatrixForm[%]

Out[244]//MatrixForm=

$$\begin{pmatrix} 1 & a & b & c & a^2 & a\,b & a\,c & b^2 & b\,c & c^2 \\ 1 & A & B & C & A^2 & A\,B & A\,C & B^2 & B\,C & C^2 \\ 1 & ay & be & si & ay^2 & ay\,be & ay\,si & be^2 & be\,si & si^2 \\ 1 & AY & BE & SE & AY^2 & AY\,BE & AY\,SE & BE^2 & BE\,SE & SE^2 \end{pmatrix}$$

```
In[245]:=
        xcross[{{1, a, b, c}, {1, A, B, C}, {1, ay , be, si}, {1, AY, BE, SI}}]

Out[245]=
        {{1, a, b, c, a b, a c, b c}, {1, A, B, C, A B, A C, B C},
         {1, ay, be, si, ay be, ay si, be si}, {1, AY, BE, SI, AY BE, AY SI, BE SI}}

In[246]:=
        MatrixForm[%]

Out[246]//MatrixForm=
```

$$\begin{pmatrix} 1 & a & b & c & a\,b & a\,c & b\,c \\ 1 & A & B & C & A\,B & A\,C & B\,C \\ 1 & ay & be & si & ay\,be & ay\,si & be\,si \\ 1 & AY & BE & SI & AY\,BE & AY\,SI & BE\,SI \end{pmatrix}$$